Toronto Metropolitan University

DEPARTMENT OF AEROSPACE ENGINEERING
FACULTY OF ENGINEERING, ARCHITECTURE AND SCIENCE

AER 715 AVIONICS AND SYSTEMS

LABORATORY 2: Flight Instruments and Cockpit Layout

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Rev 1.10.1

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0. General Safety Rules AND Regulations for Laboratories and Research Areas

The following safety rules and regulations are to be followed in all Aerospace Engineering laboratories and research facilities. These rules and regulations are to insure that all personnel working in these laboratories and research areas are protected, and that a safe working environment is maintained.

1. "Horseplay" is hazardous and will not be tolerated.

2. No student may work alone in the laboratory at any time, except to prepare operating procedures for equipment or data write-up/reduction/simulations.

3. Required personal protective equipment (PPE) will be provided by the Department for use whenever specified by the Faculty, Engineering Support or Graduate/Teaching Assistant, i.e., hearing protection, face shields, dust masks, gloves, etc.

4. Contact lenses will not be worn in the laboratory when vapours or fumes are present.

5. Safety glasses with side shields and plastic lenses will be required when operating targeted class experiments as outlined in the experimental procedures. Splash goggles or face shields will also be provided and worn also, for those experiments which have been identified as a requirement.

6. Each student must know where the location of the First Aid box, emergency equipment, eye wash station is, if required in the laboratories, shops, and storage areas.

7. All Faculty, Engineering Support and Graduate/Teaching Assistants must know how to use the emergency equipment and have the knowledge to take action when an accident has occurred, .i.e., emergency telephone number, location, emergency response services.

8. All Faculty, Engineering Support and Graduate/Teaching Assistants, and Research Assistants, must be familiar with all elements of fire safety: alarm, evacuation and assembly, fire containment and suppression, rescue.

9. Ungrounded wiring and two-wire extension cords are prohibited. Worn or frayed extension cords or those with broken connections or exposed wiring must not be used. All electrical devices must be grounded before they are turned on.

10. All Faculty, Engineering Support and Graduate/Teaching Assistants, and Research Assistants, must be familiar with an approved emergency shutdown procedure before initiating any experiment.

11. There will be NO deviation from approved equipment operating procedures.

12. All laboratory aisles and exits must remain clear and unblocked.

13. No student may sniff, breathe, or inhale any gas or vapour used or produced in any experiment.

14. All containers must be labeled as to the content, composition, and appropriate hazard warning: flammable, explosive, toxic, etc.

15. The instructions on all warning signs must be read and obeyed in all laboratories and research facilities.

16. All liquid and solid waste must be segregated for disposal according to Faculty, Engineering Support or Graduate/Teaching Assistant instructions. All acidic and alkaline waste should be neutralized prior to disposal. NOTE: NO organic waste material is to be poured down the sink or floor drains. These wastes should be property placed in designed waste disposal containers, labeled and stored in the department's flammable storage cabinet which is ventilated and secured.

17. Good housekeeping must be practiced in all teaching and research laboratories, shops, and storage areas.

18. Eating, drinking, tobacco products, gum chewing or application of makeup is strictly prohibited in the laboratories and shops.

19. Only chemicals may be placed in the "Chemicals Only" refrigerator. Only food items may be placed in the Food Only refrigerator. Ice from any refrigerator is not be used for human consumption or to cool any food or drink.

20. Glassware breakage must be disposed in the cardboard boxes marked "Glass Disposal". Any glassware breakage and malfunctioning instruments or equipment must be reported to the Faculty, Engineering Support or Graduate/Teaching Assistant present.

21. All injuries, accidents, and "near misses" must be reported to the Faculty, Engineering Support or Graduate/Teaching Assistant. The Accident Report must be completed as soon as possible after the event by the Faculty, Engineering Support or Graduate/Teaching Assistant and reported to the Departmental Safety Officer immediately. Any person involved in an accident must be sent or escorted to the University Health Centre. All accidents are to be REPORTED.

22. All chemical spills are to be reported to the Faculty, Engineering Support or Graduate/Teaching Assistant, whose direction must be followed for containment and cleanup. Faculty, Engineering Support or Graduate/Teaching Assistant will follow the prescribed instructions for cleanup and decontamination of the spill area. The Departmental Safety Officer must be notified when a major spill has been reported.

23. All students and Faculty, Engineering Support or Graduate/Teaching Assistant must wash their hands before leaving targeted laboratories, research facilities or shops.

24. No tools, supplies, or any other items may be tossed from one person to another.

25. Compressed gas cylinders must be secured at all times. Proper safety procedures must be followed when moving compressed gas cylinders. Cylinders not in use must be capped.

26. Only gauges that are marked "Use no oil" are for Oxygen cylinders. Do not use an oiled gauge for any oxidizing or reactive gas.

27. Students are never to play with compressed gas hoses or lines or point their discharges at any person.

28. Do not use adapters or try to modify any gas regulator or connection.

29. There will be no open flames or heating elements used when volatile chemicals are exposed to the air.

30. Any toxic chemicals will be only be exposed to the air in a properly ventilated Fume Hood. Flammable chemicals will be exposed to the air only under a properly ventilated hood or in an area which is adequately ventilated.

31. Personal items brought into the laboratory or research facility must be limited to those things necessary for the experiment and safe operation of the equipment in the laboratories and research facilities.

32. General laboratory coats, safety footwear are not provided by the Department of Aerospace Engineering, although some targeted laboratories and research areas will be supported by a reasonable stock of protective clothing and accessories, i.e., gloves, welding aprons, dust masks, face shields, safety glasses, etc.

33. Equipment that has been deemed unsafe must be tagged and locked out of service by the Technical Officer in charge of the laboratory or research facility. The Departmental Safety Officer must be notified of the equipment lockout IMMEDIATELY!

34. In June 1987 both the Federal & Ontario Governments passed legislation to implement the workplace hazardous material information system or WHMIS across Canada. WHMIS was designed to give workers the right-to-know about hazardous material to which they are exposed to on the job. Any person who is required to handle any hazardous material covered by this act should first read the label and the product's material safety data sheet

(MSDS). No student is to handle any hazardous materials unless supervised by a Faculty, Engineering Support or Graduate/Teaching Assistant. The laboratory Technical Officer, Faculty, Engineering Support or Graduate/Teaching Assistant is responsible for ensuring that any hazardous materials are stored safely using WHMIS recommended methods and storage procedures. All MSDS must be displayed and stored in a readily accessible place known to all users in the workplace and laboratory

35. All the foregoing rules and regulations are in addition to the Occupational Health and Safety Act, 1987.

36. Casual visitors to the laboratory and research areas are to be discouraged and must have permission from the Faculty, Engineering Support or Graduate/Teaching Assistant to enter. All visitors must adhere to the safety guidelines and is the responsibility of the visitor.

37. Only the Safety Officer may make changes to these policies upon confirmation of the Safety Committee and approval of the Department Chair.

TABLE OF CONTENTS

1. Lab Instructions

- Read the instructions in the laboratory manual carefully and follow the specified procedures.
- The lab requires teamwork. Each team has one simulator station and no more than three students.
- Download the lab manual from D2L and save it on the PC computer that you will use. Complete the lab report as indicated (☆) in the lab manual by 1) answering the pre-lab questions and printing the page; and 2) printing out the custom instrument panel that you have designed.
- At the end of the lab, submit one lab report (consisting of the above two pages and any comments and discussions that you want to add) along with the standard Ryerson Aerospace Assignment/Laboratory Cover Sheet. Each student must attend the laboratory and sign the Cover Sheet in order to receive a mark.

2. Flight Instruments and Cockpit Layout

2.1 Purpose

The objective of this lab is to familiarize students with some of the basic instruments used to fly an aircraft. In particular, the student will determine what the primary flight instruments are, and design their own custom flight instrument panel. The student will then have a chance to practice flying a Cessna 172 Skyhawk using their own flight instrument panel.

2.2 Pre-Lab Questions

STEP	DESCRIPTION/TASK
1	What are the essential flight and navigation instruments to be equipped for each pilot station?
2	The power indicators for an airplane fitted with a constant speed propeller(s) are?
3	What are the FAR 25.1321 specifications on the location of the instruments for attitude, airspeed, altitude and direction of flight?

2.3 Apparatus

- Intel Core i7 64-bit PC with Windows 7 O/S
- X-Plane ver. 8.64 flight simulation software with the Plane-Maker package
- CH Products Flight Yoke USB and CH Products Pro Pedals USB

2.4 Procedure

2.4.1 Instrument Panel Design

1. Click on the **Plane-Maker 864** icon or shortcut key from **Desktop**.
2. Go to **FILE >> OPEN**.
3. Select **>> CESSNA 172 SKYHAWK (double click) >> CESSNA 172SP.ACF** (a 3-D view of a Cessna 172 aircraft will appear on screen).
4. Go to **STANDARD >> PANEL** (a bare instrument panel of the aircraft will appear similar to Figure 1, along with a window listing numerous instrument types).

DO NOT PRESS THE "RESET" BUTTON

DO NOT USE THE "SAVE AS" MENU OPTION – ONLY SAVE YOUR PANEL

5. Scroll through the instruments and begin building your custom instrument panel by selecting the instrument to the left and dragging it to the appropriate position. Use only the primary flight instruments in the appropriate style.

   NOTE: *You can scale the instrument by adjusting the size parameter in the selection window. You can delete an instrument by selecting it and pressing the 'del' key or by dragging the instrument off of the screen.*

6. Now exit the panel section and save your aircraft.

Figure 1 Blank Cessna 172 instrument panel (sample only)

2.4.2 Basic Flying

Now that you are familiar with the cockpit instrument panel, we can learn how to perform takeoff (T/O) in a Cessna 172 and achieve a manageable steady level flight (SLF) within 5 minutes. Let's first look at the flight controls used for the flight simulator. The computer is outfitted with a flight yoke and a set of rudder pedals as shown in Figure 2 and Figure 3, respectively. The following is a description of the flight yoke's controls:

1. The Steering Column
    - Push the steering column in and out to pitch the aircraft down and up respectively. This action controls the elevators on the horizontal tail fin.
    - Rotating the column from left to right will cause the aircraft to roll. This action controls the ailerons on the wings.
2. Throttle Lever
    - Adjusts the thrust level of the engine(s)
3. Air-Fuel Mixture Lever
    - Adjusts the air-fuel mixture to the engine(s)
4. Carburetor Heat Lever
    - Used to heat up the carburetor (if freezing occurs)
5. Gear Up/Gear Down
6. Flaps Up/Flaps Down
7. Elevator Trim Tab (**For calibration only – DO NOT ADJUST**)
8. 8-Way Hat Switch
    - The switch is calibrated to display different cockpit views.
9. Elevator Trim Tab (Pitch)
10. Rudder Trim Tab (Yaw)
11. N/A
12. N/A
13. Pitch Trim Takeoff
14. Rudder Trim Centre

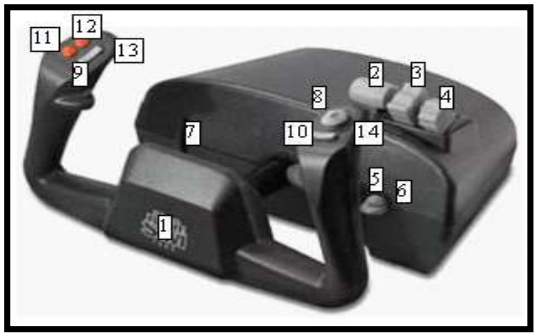

Figure 2 CH Products Flight Yoke USB

Now let's look at the foot pedals as shown in Figure 3. The pedals control the rudder on vertical tail fin, and this causes the plane to yaw. To yaw left, slide your left foot forward and your right foot back and do the opposite to yaw right. By yawing, you can pivot (turn) your aircraft without rolling the aircraft.

NOTE: Pushing the rudder pedals down applies the toe brakes.

Figure 3 Rudder pedals

Now that you have an understanding of the controls, you can begin your first flight.

NOTE: Unless your yoke or foot-pedal controls are way off for an unknown reason, you **DO NOT** need to go to **Settings >> Joystick and Equipment…** to calibrate the yoke and foot pedals for center reference and/or sensitivity adjustments as they have been pre-calibrated for you.

☆While on the runway, take a sample image of your rendered instrument panel.

Follow these instructions to customize your cockpit panel:

1. Click the **X-Plane 864** icon on the **Desktop**.
2. Wait for the program to load. When you are in the cockpit view, press "**P**".
3. Take a snapshot of the screen by pressing the "**Prt Scr**" button on the keyboard Exit the program and click on the **Irfan View** icon. Paste your custom panel into the program by pressing "**Ctrl-V**" (or **Edit >> Paste**).
4. Print your custom panel by making the following selections:
    - **File >> Print >> Setup Tab >> Landscape >> Print**
    - Select "**Best Fit to Page**" and "**Center Image**" **>> Print**
5. Exit.
6. **Hand this in along with your pre-lab questions.**

Follow these instructions to fly your plane:

1. Click the **X-Plane 864** icon on the Desktop.
2. Wait for the program to load. When you are in the cockpit view, press "**P**".
3. Adjust your primary levers (throttle, fuel, carb) levers off (fully towards you) and engage your toe breaks. Press "**P**" again to un-pause.
4. Wait until you are settled on the runway in your Cessna 172 Skyhawk **(make sure your thrust lever is not engaged or you will start to turn on the runway**).
5. Increase your fuel mixture.
6. To start your engine, hold down the "red" start button with the left mouse button and slowly increase the thrust lever.
7. Hit the "**Flap**" tab **two (2) times** to bring in some flaps for takeoff.
8. Disengage the brakes (Click the orange brake button or press the "**B**" key to toggle the brakes on and off). **KEEP YOUR TOE BREAKS ON**.
9. Operate the throttle by pushing the lever forward all the way to go to full power while slowly releasing your toe breaks. Make sure your air-fuel ratio is also fully forward.
10. Pull the yoke back lightly to rotate and take-off at about **80 knots (V_r speed)**.
11. Upon reaching **1,000 feet** or so, throttle back to about **80% (Green Zone)**.
12. Hit the "**Flap**" tab **two (2) times** to retract the flaps.
13. Fly the plane for a few minutes with the controls. You should be able to achieve **SLF @1,000 ft** within **5 minutes**.
14. Select "**Quit**" from the "**File**" Menu.

NOTE 1: While flying, take a look at the various instruments as you pitch, yaw, roll and while you play with the other controls.

NOTE 2: Pressing the "**A**" key will give a forward view behind the aircraft's tail. Using the arrow keys in this mode will adjust the camera view around the aircraft. Pressing "**W**" will return you to the cockpit view.

NOTE 3: To adjust the view to use dual monitors, perform the following steps:

1. **Settings >> Rendering Options…**
2. Adjust the Screen Resolution. Set the **horizontal** pixel number to **2x** a single monitor resolution and the **vertical** to **1x** the resolution (right click on the desktop to determine the resolution). For instance, if the resolution in Windows is1280 x 1024, then set the resolution to 2560 x 1024.
3. Field of View: Set to **160 degrees**.
4. Min Frame Rate: Set to **24 (fps)**.
5. Exit and reopen **X-Plane 864**.

3. References

[1] Transport Canada. Flight Training Manual, 3'rd edition. Gage Publishing Ltd., Toronto, 1983.

[2] Laminar Research. X-Plane On-line Instruction Manual. 2009.

[3] Ian Moir, Allan Seabridge, and Malcolm Jukes. Civil Avionics Systems. John Wiley & Sons Ltd., 2013

[4] Liu, G. AER715 Lecture Notes. 2017.